# Irradiation-induced effects in organic thin PMMA films

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Individual heavy ions impacting insulators at high velocities (few tenths of MeV/u or higher) cause the ejection of material and plastic deformation at the surface, resulting in permanent rims and craters [1-4]. Recent studies on the interaction of individual ions in polymeric thin films indicate that the surface effects are altered as the thickness of the material is reduced [5]. The effects of fast ions on confined structures are not completely understood [6] and may vary from those observed for bulk matter. In this contribution, we report on the impact features produced by 4.8 MeV/u Pb ions on poly(methyl methacrylate) (PMMA) films as a function of the thickness *t* at normal incidence. The results observed indicated a clear thickness dependent effect on the crater formation process for very thin layers.

Thin films of PMMA were spin-coated onto Si substrates with a thicknesses *t* ranging from 2 to 100 nm. The films were bombarded with 4.8 MeV/u Pb ions at a fluence of ~$10^8$ $cm^{-2}$ at the UNILAC accelerator. The size and shape of the surface tracks were characterized offline with a Nanoscope IIIa scanning force microscope (SFM).

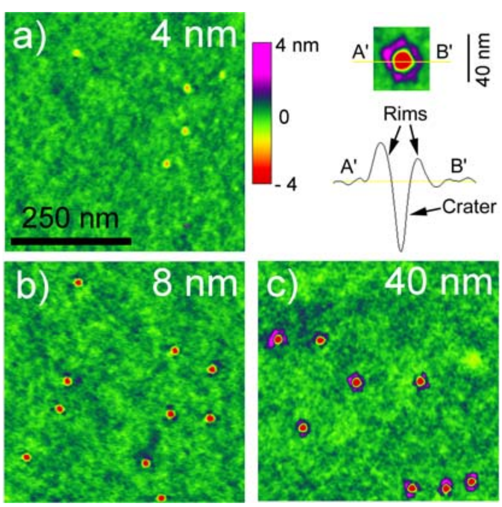


Figure 1: SFM images of PMMA films of indicated thickness, bombarded normal to the surface by 4.8 MeV/u Pb ions. The inset shows typical profile of impact features.

Typical images of impact features at normal beam incidence are shown in Fig. 1. For the thicker films, two different structures are observed at the impact site: crater-like holes and rims. Figure 2 and 3 depict quantitative data on the averaged sizes of rims and craters as a function of thickness *t*, respectively. For a critical thickness, the impact features show changes in size and morphology: below 40 nm, the rim volume decreases linearly and disappears completely below *t* ~ 4 nm. This strong change of rim dimension indicates a deeper depth of origin for protrusion formation, related to long-range cooperative interactions. The crater dimensions on the other hand, showed only slight changes even for very thin samples, reducing from ~20 nm for thicker layers down to ~15 nm for the thinnest films. The weaker thickness effect suggests their formation is very much dependent on the near surface excitation events, as was indicated recently by charge-state dependent impact craters produced with 600-MeV Au ions [5].

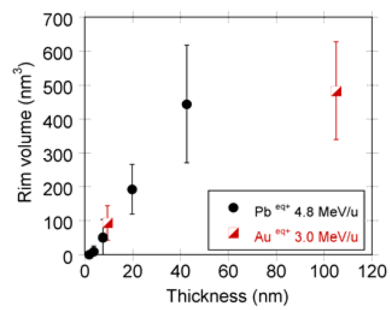


Figure 2: Average volume of rims produced by 4.8 MeV/u Pb ions and 3.0 MeV/u Au ions [5] on PMMA films of different thickness.

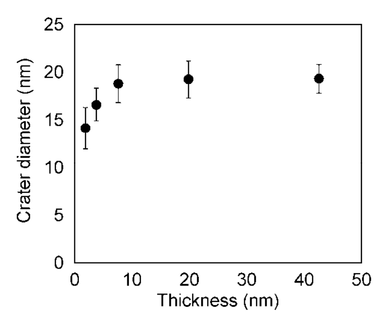


Figure 3: Average diameter of craters produced by 4.8 MeV/u Pb ions on PMMA films of different thickness.

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